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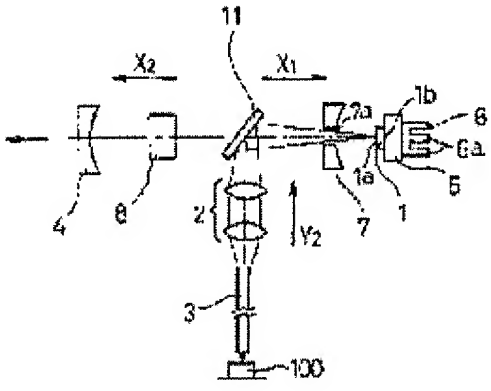
(54) OSCILLATION METHOD FOR LD EXCITATION LASER, LASER OSCILLATOR, AND LASER MACHINING DEVICE

(57)Abstract:



PROBLEM TO BE SOLVED: To cast a good laser light beam and provide a highly accurate machining.

SOLUTION: By using Yb:YAG or Nd:YVO4, which is made thin because of the high efficiency in oscillation as a laser medium, a first edge face 1a is irradiated with a light beam from a laser diode(LD) 100 and excited. The laser beam oscillated from the first edge face 1a of a laser medium 1 is reciprocated between a first edge face 1a and a second mirror 5 put at a second edge face 1b in the laser medium 1. Then, the laser beam with sufficient output can be made to exit from the reciprocated optical path, while the thin laser medium 1 is cooled effectively from

the rear part of the second mirror 5 by using a cooling means 6.

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[Claim(s)]

[Claim 1] In the LD excitation laser oscillation approach which excites a laser medium, and a laser medium is made to go and come back to by the mirror which counters the oscillation laser beam from the laser medium by this LD excitation on both sides of a laser medium, amplifies, and carries out outgoing radiation with the light from LD The 1st mirror which counters the laser beam which makes Yb:YAG a thin shape, uses it for a laser medium, irradiates the light from LD, excites it to that 1st end face, and is oscillated from the 1st end face of Yb:YAG with this 1st end face, The LD excitation laser oscillation approach characterized by combining with hitting against the 1st end face of Yb:YAG, and the 2nd end face of the opposite side, making it go by the 2nd mirror of ******, and carrying out outgoing radiation out of this both-way optical path, and cooling Yb:YAG behind behind the 2nd mirror.

[Claim 2] The thickness of Yb:YAG is the LD excitation laser oscillation approach according to claim 1 which is 0.5mm or less.

[Claim 3] In LD excitation laser oscillation machine which irradiates the light from LD at a laser medium, and excites this, and a laser medium is made to go and come back to by the 1st and 2nd mirror which counters the oscillation laser beam from the laser medium by this LD excitation on both sides of a laser medium, amplifies, and carries out outgoing radiation Have thin Yb:YAG as a laser medium and the 1st mirror is made to counter the 1st end face of this Yb:YAG. the 2nd end face of the opposite side of the 1st end face of Yb:YAG -- the 2nd mirror -- reliance -- it is -- the regions of back of the 2nd mirror -- a cooling means -- guessing -- ****** -- LD excitation laser oscillation machine characterized by things.

[Claim 4] The excitation light from LD is LD excitation laser oscillation machine according to claim 3 made to irradiate the 1st end face of Yb:YAG from on the both-way optical path to which said laser beam is made to go and come back with the dichroic mirror which this is reflected [dichroic mirror] and makes the laser beam from Yb:YAG penetrate.

[Claim 5] The laser beam on the both-way optical path to which said laser beam is made to go and come back is LD excitation laser oscillation machine given in any 1 term of claims 3 and 4 which carry out outgoing radiation by the 1st mirror which carries out the partial transparency of the laser beam, or the beam splitter placed on the both-way optical path.

[Claim 6] The 2nd mirror is LD excitation laser oscillation machine given in any 1 term of claims 3-5 which consists of sapphire or a diamond with the optical flat surface.

[Claim 7] A laser beam is LD excitation laser oscillation machine given in any 1 term of claims 3-6 modulated with a Q switch.

[Claim 8] LD excitation laser oscillation machine given in any 1 term of claims 3-7 equipped with aperture with the hole which is located on a both-way optical path, is made to reflect excitation light and a laser beam in a 1st [of Yb:YAG] end-face side, and is in agreement with the predetermined cross-section configuration of a laser beam.

[Claim 9] An antireflection film is given to the 1st and 2nd end face of Yb:YAG to the wavelength of a laser beam. The monitor which gives the total reflection film to which a tooth back is made to carry out total reflection of the laser beam for the lambda/4-wave film made to change the phase of a laser beam into the front face of the 2nd mirror, respectively, is located behind the 1st mirror, and detects the leakage light from the 1st mirror, LD excitation laser oscillation machine given in any 1 term of claims 3-8 equipped with the rolling mechanism which makes an optical axis rotate the 2nd mirror to the circumference of an optical axis on a right-angled flat surface, and the controller which controls the output of a laser beam by operating said rolling mechanism according to the detection value in said monitor.

[Claim 10] LD excitation laser oscillation machine [equipped with the wavelength sensing element which short-wavelength-izes the laser beam which carried out outgoing radiation, and outputs it from the both-way optical path to which a laser beam is made to go and come back] according to claim 9.

[Claim 11] LD excitation laser oscillation machine given in any 1 term of claims 9 and 10 equipped with the etalon which combines, is put on the beam splitter which carries out outgoing radiation of the laser beam to a both-way optical path, and narrow-band-izes luminescence width of face of a laser beam.

[Claim 12] LD excitation laser oscillation machine given in any 1 term of claims 3-11 replace with Yb:YAG as a laser medium and using Nd:YVO4.

[Claim 13] In laser-beam-machining equipment equipped with LD excitation laser oscillation machine which irradiates the light from LD at a laser medium, and excites this, and the oscillation laser beam from the laser medium by this LD excitation is made to go and come back to by the mirror which counters on both sides of a laser medium, amplifies, and carries out outgoing radiation a laser oscillation machine LD arranged so that excitation light may be irradiated at the 1st end face of thin Yb:YAG as a laser medium or Nd:YVO4, and this Yb:YAG or Nd:YVO4, By making it reflect in the opposite location which sandwiches a laser medium, and making the laser beam oscillated from

the 1st end face go The 2nd mirror to which reliance was divided into the 1st end face of the 1st mirror which countered the 1st end face arranged so that it may amplify and outgoing radiation may be carried out out of this both-way optical path and Yb:YAG, or Nd:YVO4, and the 2nd reverse near end face, A condensing means to be equipped with the cooling means with which reliance broke behind this 2nd mirror, and to condense the laser beam from a laser oscillation machine on a processing side, A scan means to deflect this laser beam condensed and to scan a processing side top, Laser-beam-machining equipment characterized by establishing a condensing amendment means to amend so that this laser beam scanned may be condensed on a processing side, and an observation means to picturize and observe the condensing location to the processing side top of a laser beam through said scan means and a condensing amendment means.

[Claim 14] It is laser-beam-machining equipment according to claim 13 whose scan means is the galvanomirror of the pair which scans a processing side top by the laser beam to the 2-way which intersects perpendicularly and whose condensing amendment means is ftheta lens.

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the LD excitation laser oscillation approach, a laser oscillation machine, and the laser-beam-machining equipment by this.

[0002]

[Description of the Prior Art] In recent years, LD excitation laser oscillation machine excited by the light from LD (laser diode) which suited the absorption wavelength of a laser oscillation machine of a laser medium instead of the laser oscillation machine excited with a flash lamp or an arc lamp is commercialized. Compared with a lamp excitation laser oscillation machine, LD excitation laser oscillation machine has few supply voltages, and does not have a maintenance called lamp replacement. Moreover, the laser oscillation machine itself is small. There is a said advantage and it is provided widely.

[0003] There is a thing as shown in drawing 5 in the conventional LD excitation laser oscillation machine. This thing leads the light from LD which is not illustrated to the collimator lens 102 of a pair with an optical fiber 103, and fabricates it, and the excitation light which passed through the collimator lens 102 makes the dichroic mirror 106 which is made to penetrate this and is made to reflect a laser beam penetrate, irradiates the end side of the laser medium 101, and excites the laser medium 101.

Generally Nd:YAG is used for the laser medium 101. However, Nd:YLE etc. may be used. Since the absorption becomes max to the wavelength of 808nm, it is used for LD to which the oscillation wavelength of LD light also makes 808nm peak value by such laser medium 101, choosing. In order to enlarge an output, performing the same LD excitation as the both-ends side of the laser medium 101 like the example shown in drawing 5 is also performed.

[0004] The laser beam in which outgoing radiation is carried out by these LD excitation from the laser medium 101 is made to output as an about 1064nm laser beam from a laser oscillation machine, when it amplifies by making it reflect between the total reflection mirrors 104 and the partial transparency mirrors 105 which counter on both sides of the laser medium 101, and making it go and the amplified laser beam penetrates the partial transparency mirror 105. For example, Nd not more than output 10W: The laser medium 101 is carrying out the configuration of the prism of several mm angle, or the cylinder of a several mm diameter, and it is hard to cool directly, is cooled by the cooling section of a Peltier device, or water cooling from the circumference of the other side periphery, and make it the edge surface part which receives LD excitation have the temperature up prevented in an YAG laser oscillator.

[0005] In addition, on the occasion of laser beam machining, pulse-izing is performed by Q switch 108 placed in the middle of the both-way optical path which makes the output of a laser beam by which continuation outgoing radiation is carried out from the laser medium 101 go and come back to a laser beam if needed, a beam splitter 110 separates a part of laser beam by which outgoing radiation was carried out, it leads to a monitor 109, and controlling the output of a laser beam based on the detection value of this is also performed.

[0006] It is also performed that wavelength of the laser beam which carries out outgoing radiation from the laser medium 101 is shortened with 1/2, 1/3, and 1/4 on the other hand, and it can be made to perform more detailed processing. This considers as the laser oscillation machine oscillated by 523nm, 355nm, and 264nm by said short wavelength-ization, when said output wavelength is 1064nm. Drawing 6 shows the conventional example for which the wavelength sensing element 207 was used in order to short-wavelength-ize an oscillation laser beam such. The excitation light which passed through the fiber 203 and the collimator lens 202 Through the dichroic mirror 204 which is made to penetrate this and is made to reflect a laser beam, irradiate the laser medium 201 and it excites. Although the oscillation laser beam from the laser medium 201 is made to go between said dichroic mirror 204 and the partial transparency mirror 205, it amplifies and outgoing radiation of the partial transparency

mirror 205 is penetrated and carried out The wavelength sensing element 207 is placed in the middle of the both-way optical path of a laser beam, and whenever a laser beam passes, it short-wavelength-izes it. The partial transparency mirror 205 carries out outgoing radiation only of the laser beam short-wavelength-ized by the predetermined rate. KTP, LBO, etc. may be used for the wavelength sensing element 207, and temperature control may be carried out so that a chip temperature may become fixed.

[0007]

[Problem(s) to be Solved by the Invention] However, in the case of the conventional LD excitation laser oscillation machine which adopted above-mentioned Nd:YAG, it corresponds to the demand of the further highly-precise-izing of processing, and does not go out.

[0008] The so-called thermal lensing effect by the variation in the temperature distribution of the laser medium 101 will produce the 1st technical problem. the edge surface part which LD excitation is carried out and carries out outgoing radiation of the laser beam although the laser media 101 and 201 of Nd:YAG are forming the above pillar-shaped objects and this is cooled from the circumference of a side periphery -- cooling -- and -- being hard -- it is the phenomenon in which the end face to which variation arises in a sake at temperature distribution, and temperature becomes high rather than other parts carries out heat deformation by thermal expansion at a convex lens configuration. A heat lens phenomenon gives a focal property to an end face. The focal die length changes with the excitation output values from LD. For example, it is not excited, namely, when an excitation output is zero, the end face of the laser media 101 and 201 is a flat surface, and focal die length serves as infinity. If it becomes a value with an excitation output, a thermal lensing effect will increase and focal die length will become short at a certain value. Therefore, focal die length results in change to the divergence angle of beams and the configuration of a laser beam which carry out merits-and-demerits change by the size of an excitation output and which carry out outgoing radiation from the laser media 101 and 201.

[0009] Passing only the fixed path of the laser beam from which a configuration changes, and excepting the laser beam besides a fixed path by the aperture which has a fixed path in order to lose the effect of change of the shape of beam of a laser beam, is performed. Moreover, in order to ease the effect of a thermal lensing effect, the end face of the laser media 101 and 201 is beforehand made into concave, and it may be designed so that an end face may become at a flat surface by the thermal lensing effect at the time of a certain excitation output. However, the thermal lensing effect is not canceled by these cases, either. Aperture will be designed according to the diameter of min of the

beam divergence angle of the laser beam sharply changed according to a thermal lensing effect by the aperture method, and since the laser beam to which a path becomes large rather than it is kicked around aperture, the ratio of consumed water of the laser beam by which outgoing radiation is carried out from the laser media 101 and 201 falls greatly. Moreover, by the method which makes the end face concave beforehand, a thermal lensing effect is only canceled at the time of the predetermined excitation output from which an end face turns into a flat surface. Moreover, the variation in the temperature distribution produced to the laser media 101 and 201 brings about change of a refractive index, and produces the heat birefringence that a polarization component changes.

[0010] These pose a problem, while still higher process tolerance is required, a thermal lensing effect and a heat birefringence become min regardless of an excitation output, namely, a LD excitation laser oscillation machine with which the shape of beam of a laser beam, an angle of divergence, a polarization component, and the good laser output from which an output does not change are obtained is desired.

[0011] If the 2nd technical problem tends to control a laser output and it is going to maintain it at constant value, it needs to change the output of LD. In this case, if the output of LD is changed, the oscillation wavelength of the excitation light from LD will change, and the excitation absorption-of-light multiplier in the laser media 101 and 201 will change. For this reason, since a laser output does not become a predetermined value only by controlling an excitation output to a command value but change of a laser output becomes large, this also influences process tolerance.

[0012] Even when micro processing can be made to perform the 3rd technical problem using a wavelength sensing element, the variation in the laser output of the fundamental wavelength and the shape of beam of a laser beam cannot be canceled, but this also influences process tolerance.

[0013] In the processing machine which carries out laser beam machining with LD excitation laser oscillation vessel which the above thermal lensing effects and a heat birefringence produce, even if the 4th technical problem tends to set up working speed and a processing output according to the class of processing and tends to acquire a fixed processing condition with high precision by fixed processing, for example, a fixed energy density, since a processing condition changes, it cannot realize highly precise processing.

[0014] The purpose of this invention is to offer the LD excitation laser oscillation approach which can carry out outgoing radiation of the good laser beam, and can perform highly precise processing, a laser oscillation machine, and the laser-beam-machining equipment by this.

[0015]

[Means for Solving the Problem] Although the LD excitation laser oscillation approach of this invention excites a laser medium, and the oscillation laser beam from the laser medium by this LD excitation is made to go and come back to it between the mirrors which counter, it is amplified and carries out outgoing radiation with the light from LD The 1st mirror which counters the laser beam which makes Yb:YAG a thin shape, uses it for a laser medium, irradiates the light from LD, excites it to that 1st end face, and is oscillated from the 1st end face of Yb:YAG with this 1st end face, It combines with hitting against the 1st end face of Yb:YAG, and the 2nd end face of the opposite side, making it go between the 2nd mirror of ******, and carrying out outgoing radiation out of this both-way optical path, and is characterized [one] by cooling Yb:YAG behind behind the 2nd mirror.

[0016] Thus, if it replaces with Nd:YAG generally used from the former as a laser medium in LD excitation laser oscillation machine and Yb:YAG is used, the rate of doping can be raised, and exoergic effectiveness will compare with Nd:YAG and will become high several times. For this reason, in order to obtain the same laser output, Yb:YAG becomes good by 1/dozens of Nd:YAG. Therefore, make Yb:YAG into a thin shape as mentioned above, and the 1st mirror is made to turn and oscillate a laser beam by LD excitation as usual from the 1st end face of one of these. By making this go between the 1st and 2nd mirror which sandwiched the laser medium, and amplifying it while securing sufficient laser output value required for processing -- the 2nd mirror -- the 1st end face of a laser medium, and the 2nd reverse near end face -- reliance -- ****, even if it cools a laser medium, without interfering with LD excitation behind behind the 2nd mirror Since the variation in temperature distribution including the 1st end face by which the cooling effect tends to attain to thin whole Yb:YAG, and LD excitation of the laser medium is carried out becomes small The thermal lensing effect in the end face by it and generating of the heat birefringence by change of a refractive index can be suppressed, the energy of a laser output and fluctuation of the shape of beam can be reduced, and it is useful to improvement in the further process tolerance. It is suitable for the thickness of Yb:YAG on said cooling effect that it is 0.5mm or less.

[0017] LD excitation laser oscillation machine of this invention irradiates the light from LD at a laser medium, and excites this. In what a laser medium is made to go and come back to, amplifies, and carries out outgoing radiation by the 1st and 2nd mirror which counters the oscillation laser beam from the laser medium by this LD excitation on both sides of a laser medium Have thin Yb:YAG as a laser medium and the 1st mirror is made to counter the 1st end face of this Yb:YAG. The 2nd mirror of reliance is in the 2nd

end face of the opposite side of the 1st end face of Yb:YAG. the regions of back of the 2nd mirror -- a cooling means -- guessing -- ****** -- it can be characterized [one] by things and characteristic arrangement with adoption, the 2nd mirror to this, and cooling means of thin Yb:YAG can realize invention of the above-mentioned approach.

[0018] The 1st end face of Yb:YAG can be made to be able to irradiate from on the both-way optical path of said laser beam with the dichroic mirror which the excitation light from LD reflects [dichroic mirror] this and makes the laser beam from Yb:YAG penetrate, and outgoing radiation of the laser beam on a both-way optical path can be carried out by the 1st mirror which carries out the partial transparency of the laser beam, or the beam splitter placed on the both-way optical path. When are based on a beam splitter, and outgoing radiation only of the specific deviation component is divided, extracted and carried out, the variation in an output is suppressed further, and is stabilized and further improvement in process tolerance can be aimed at, other deviation components which make the 1st and 2nd mirror a total reflection side, and are not extracted by the beam splitter can be made to be able to go, and it can use effectively for excitation of a laser medium.

[0019] Since the 2nd mirror can offer highly precise transparency and the reflective engine performance to a laser beam as it is what consists of sapphire or a diamond with the optical flat surface, and its thermal conductivity is good and it can heighten the cooling effect of the laser medium by the cooling means in back, it can suppress generating of a thermal lensing effect and a heat birefringence more, and can improve the precision of laser beam machining more.

[0020] Also when absent, a laser beam is modulated with a Q switch and it does not bar pulse-izing a continuous-oscillation condition and outputting it. If it has aperture with the hole which is located on a both-way optical path, is made to reflect excitation light and a laser beam in a 1st [of Yb:YAG] end-face side, and is in agreement with the predetermined cross-section configuration of a laser beam Aperture excepts the laser beam from which it separated from the diameter of a convention although it had decreased by reduction of fluctuation of the shape of beam. Stability of a laser output and improvement in process tolerance can be aimed at, further, by aperture, it is made to reflect in a 1st end-face side, and the laser beam from which it separated from the diameter of a convention can be used effectively for excitation of a laser medium. In this case, if aperture has the condensing predetermined curvature by the side of the 1st end face, since the rate of condensing to the 1st end face of said excepted laser beam will be raised, that rate of a deployment is raised to the maximum.

[0021] Furthermore, an antireflection film is given to the 1st and 2nd end face to the

wavelength of a laser beam. The monitor which gives the total reflection film to which a tooth back is made to carry out total reflection of the laser beam for the lambda/4-wave film made to change the phase of a laser beam into the front face of the 2nd mirror, respectively, is located behind the 2nd mirror, and detects the leakage light from the 2nd mirror, It should have the rolling mechanism which rotates the 2nd mirror to the circumference of an optical axis on a right-angled flat surface to a laser beam, and the controller which controls the output of a laser beam by operating said rolling mechanism according to the detection value in said monitor.

[0022] Although what is necessary is just to change an excitation optical output to changing the output from a laser medium, as described above, by Nd:YAG, an excitation optical output has the problem from which wavelength changes with laser outputs a little, and the rate of excitation light absorption of a laser medium changes with change of the wavelength of this excitation light. However, since it of Yb:YAG to which the antireflection film was given as mentioned above to the absorption wavelength width of face of Nd:YAG in the both-ends side is about ten times and the range of fluctuation of the oscillation wavelength of LD is less than [it], even if it changes the laser output from a laser medium by changing the excitation output from LD, a problem is lost, and it becomes easy to change a laser output.

[0023] And going, when the laser beam which penetrates Yb:YAG penetrates the lambda/4-wave film of the front face of the 2nd mirror, and when penetrating the total reflection film of the tooth back of the 2nd mirror, plane of polarization changes, and the deviation component ratio to other deviation light which is not extracted by the beam splitter of a predetermined deviation light extracted by the beam splitter changes. Then, the output of a laser beam by which outgoing radiation is extracted and carried out without changing the deviation side of a laser beam, setting up a deviation component ratio freely and changing the excitation output of LD by rotating the 2nd mirror, carrying out the monitor of the light which leaks from the 1st mirror as mentioned above can be made to fluctuate.

[0024] Suppose that it should have the wavelength sensing element which short-wavelength-izes the laser beam which carried out outgoing radiation from the both-way optical path, and outputs it in the above. Since a wavelength sensing element changes into short wavelength only light with the fixed polarization component extracted by the beam splitter The light of an excessive polarization component does not irradiate a wavelength sensing element, and bring damage on a component forward by the exposure of an excessive deviation component, and a thermal lensing effect is caused to a component. Since it seems that the output of the light after wavelength

conversion and the shape of beam are not changed, incidence only of the fixed polarization component can be carried out to a wavelength sensing element, and a short wavelength beam good without the effect of an excessive deviation component can be made to output.

[0025] It should combine, should be put on the beam splitter which carries out outgoing radiation of the laser beam to the both-way optical path to which a laser beam is made to go and come back, and should have further the etalon which narrow-band-izes luminescence width of face of a laser beam.

[0026] The laser oscillation machine using Yb:YAG has large fluorescence width of face compared with Nd:YAG. Therefore, when condensing with a condenser lens, chromatic aberration arises, pin dotage tends to take place, and it is hard to attain micro processing. In order to prevent this chromatic aberration, narrow-band-ization which narrows oscillation wavelength fluorescence width of face is needed. Since an etalon makes wavelength of the light which carries out incidence predetermined single wavelength and it can fabricate a beam more thinly, it is convenient to micro processing.

[0027] As a laser medium of each **** of the above-mentioned LD excitation laser oscillation approach and a laser oscillation machine, it can replace with Yb:YAG and Nd:YVO4 can be used. Since it becomes more highly [the rate of the excitation absorption of light is high, and] than Nd:YAG like [Nd:YVO4] the case of Yb:YAG several times [oscillation effectiveness] according to increase of the amount of dopes, the operation same as 0.5mm or less can be done so like the case of Yb:YAG.

[0028] The laser-beam-machining equipment of this invention irradiates the light from LD at a laser medium, and excites this. In the thing equipped with LD excitation laser oscillation machine to which the oscillation laser beam from the laser medium by this LD excitation is made to go by the mirror which counters on both sides of a laser medium, is amplified, and carries out outgoing radiation Yb:YAG or Nd:YVO4 of the thin shape [machine / laser oscillation] as a laser medium, LD arranged so that excitation light may be irradiated at the 1st end face of this Yb:YAG or Nd:YVO4, By making it reflect in the opposite location which sandwiches a laser medium, and making the laser beam oscillated from the 1st end face go The 2nd mirror to which reliance was divided into the 1st end face of the 1st mirror which countered the 1st end face arranged so that it may amplify and outgoing radiation may be carried out out of this both-way optical path and Yb:YAG, or Nd:YVO4, and the 2nd reverse near end face, A condensing means to be equipped with the cooling means with which reliance broke behind this 2nd mirror, and to condense the laser beam from a laser oscillation machine on a processing side, A scan means to deflect this laser beam condensed and to scan a processing side

top, It is characterized [one] by establishing a condensing amendment means to amend so that this laser beam scanned may be condensed on a processing side, and an observation means to picturize and observe the condensing location to the processing side top of a laser beam through said scan means and a condensing amendment means.

[0029] While this observes the condition of a processing point on the basis of the stable predetermined conditions using the laser beam of mitigation of the heat lens by above-mentioned Yb:YAG or Nd:YVO4, and a heat birefringence, short wavelength, and a narrow-band, detailed processing of workpiece etc. can be attained with high precision.

[0030] It is suitable that a scan means is the galvanomirror of the pair scanned by the laser beam to the 2-way which intersects a processing side top perpendicularly, and it is suitable that a condensing amendment means is ftheta lens.

[0031] The purpose and the description beyond it of this invention become clear by the publication of the following detailed explanation and a drawing. each description of this invention is boiled as much as possible, is set, and is independent [its], or various -- it can combine, come out, compound and use.

[0032]

[Embodiment of the Invention] The LD excitation laser oscillation approach of the gestalt some operations of this invention, a laser oscillation machine, and the laser beam machine using these are explained hereafter, referring to drawing 1 R> 1 - drawing 4 with an example, and an understanding of this invention is presented.

[0033] The gestalt of this operation shown in drawing 1 is an example in the case of a LD excitation Yb:YAG laser oscillator. Incidence of the excitation light with a wavelength of 940nm oscillated from LD100 is carried out to the collimator lens 2 of a pair through an optical fiber 3. the excitation light to which incidence of the collimator lens 2 is carried out -- Taira -- after making it a Yukimitsu beam, outgoing radiation is fabricated and carried out to a beam with a diameter of 1mm or less, and incidence of this is carried out to one end-face 1a of Yb:YAG laser 1 which is a laser medium. The dichroic mirror 11 which makes a laser beam with a wavelength of 1030nm which is made to reflect excitation light with a wavelength of 940nm, and carries out outgoing radiation from Yb:YAG laser 1 for this incidence penetrate is formed, and it is the excitation light from LD100 by this dichroic mirror 11 Y2 A direction to X1 It bends in a direction and one end-face 1a of Yb:YAG laser 1 is made to condense. Yb: YAG laser 1 can irradiate excitation light in this way, and while was excited and it carries out outgoing radiation of the laser beam with a wavelength of 1030nm from end-face 1a. The laser beam of this wavelength 1030 is a dichroic mirror 11X2. It penetrates in a direction, and it is reached and reflected by the output mirror 4 which is a partial

transparency mirror, a dichroic mirror 11 is penetrated, and it returns to Yb:YAG laser 1.

[0034] Here, with the gestalt of this operation, since Yb:YAG laser 1 can take the rate of doping of Yb to about 50%, its rate of the excitation absorption of light improves, and the rate of an oscillation of a laser beam compares with Nd:YAG used conventionally, and becomes high with about 3.4 times. Therefore, in order to obtain the same laser output, Yb:YAG laser 1 becomes good in the magnitude of the abbreviation 1/20 of Nd:YAG. Then, although the laser beam which has returned to said Yb:YAG laser 1 is made to go between the output mirrors 4 and the rear mirrors 5 which sandwich Yb:YAG laser 1 and is amplified while using by making Yb:YAG laser 1 into a thin shape using this the rear mirror 5 -- Yb: -- while preparing so that the rear mirror 5 of YAG laser 1 and other-end side 1b which counters may be contacted, Yb:YAG laser 1 is cooled with the refrigeration unit 6 made to contact the one end side which is the regions of back of the rear mirror 5.

[0035] Thus, Yb:YAG laser 1 is made into a thin shape, from the 1st end-face 1a of one of these, it is alike as usual, LD excitation is carried out, and a laser beam is oscillated. Yb: Said oscillated laser beam can be made to be able to go several times between the output mirrors 4 and the rear mirrors 5 which sandwiched YAG laser 1, it can amplify, and sufficient laser output value required for processing can be secured only by the laser beam of predetermined amplification degree making the output mirror 4 penetrate and output. moreover, this, simultaneously the rear mirror 5 -- 1st end-face 1a of Yb:YAG laser 1, and 2nd reverse near end-face 1b -- reliance -- ****, even if it cools Yb:YAG laser 1 with a refrigeration unit 6 that there is no obstacle of LD excitation from behind the rear mirror 5 Yb of a thin shape [cooling effect / the]: It is easy to attain to whole YAG laser 1, and the variation in the temperature distribution of the whole including 1st end-face 1a excited by the excitation light from LD100 becomes small. Therefore, Yb: The thermal lensing effect of YAG laser 1 and generating of the heat birefringence by change of a refractive index can be suppressed, and the energy of a laser output and fluctuation of the shape of beam can be reduced. It is useful to improvement in the further process tolerance with this. In addition, as an example, it is suitable for the thickness of Yb:YAG laser 1 on said cooling effect that it is 0.5mm or less. However, it is not restricted to this.

[0036] a refrigeration unit 6 -- Yb: -- preparing radiation-fin 6a in the tooth back of the cooling block which consists of good aluminum of heat conduction etc. as shown in drawing 1 , cooling naturally, when the laser output from YAG laser 1 is the Koide force, or spraying cold blast on the part of this radiation-fin 6a, and carrying out forced cooling

**** -- or the cold end of a Peltier device -- the tooth back of the rear mirror 5 -- reliance -- **** -- forced cooling is carried out and the cooling effect required for each **** should just be acquired. Moreover, in high power, into a cooling block, the method which circulates cooling media, such as cold water, can be adopted, and the cooling effect can also be heightened.

[0037] In addition, as an example, the rear mirror 5 should be formed with sapphire or a diamond with the optical flat surface. Yb by the refrigeration unit 6 in back since according to this a highly precise transparency property can be offered to a laser beam and thermal conductivity is good: The cooling effect of YAG laser 1 can be heightened. Therefore, generating of a thermal lensing effect and a heat birefringence can be suppressed more, and the precision of laser beam machining can be improved more.

[0038] With the gestalt of this operation, it becomes irregular including any case of an example with Q switch 8 which prepares a laser beam in the location which separated from the exposure optical path of the excitation light on the both-way optical path, and the continuous-oscillation condition of a laser beam can be pulse-ized, and can be outputted. Thereby, digital control of the output of a laser beam is carried out, and it becomes easy to process workpiece by various kinds of patterns. Moreover, if it has the aperture 7 with hole 7a which is located on a both-way optical path, is made to reflect excitation light and a laser beam in the 1st [of Yb:YAG laser 1] end-face 1a side like the example shown in drawing 1 , and is in agreement with the predetermined beam cross-section configuration of a laser beam Although it has decreased by reduction of fluctuation of the shape of beam of a laser beam, the laser beam from which it separated from the diameter of a convention can be excepted, and stability of the shape of beam of a laser output and improvement in process tolerance can be aimed at. Furthermore, aperture 7 makes it reflect in a 1st end-face side, and can use effectively for excitation of a laser medium, and since aperture 7 makes 1st end-face 1a condense said excepted laser beam by having the condensing curvature by the side of 1st end-face 1a as shown in drawing 1 , the rate of reuse which excites Yb:YAG laser 1 improves.

[0039] The gestalt of operation shown in drawing 2 is an example in the case of LD excitation laser oscillation machine the output was made to be changed by outputting only the fixed polarization component of the laser beams oscillated from Yb:YAG laser 21, and changing a polarization component ratio.

[0040] The main optical structures of the gestalt of operation shown in drawing 2 are replaced with the output mirror 4 of the gestalt of operation of said drawing 1 turning and reflecting in 1st end-face 21a of Yb:YAG laser 21 the laser beam by which outgoing radiation is carried out from Yb:YAG laser 21, and the total reflection mirror 14 to

which coating of the total reflection film which carries out total reflection of the laser beam to a reflector was carried out is used for them. However, a total reflection mirror 14 has several% of leakage light. Moreover, only a polarization component with a laser beam is reflected in the location from which it separated from the exposure optical path of the excitation light from LD100 of the both-way optical paths to which a laser beam is made to go and come back between the output mirrors 14 and the rear mirrors 15 which sandwiched Yb:YAG laser 21, and the beam splitter 12 which makes other polarization components penetrate is arranged with Q switch 8. Specifically, the beam splitter 12 is arranged between the dichroic mirror 11 and Q switch 8.

[0041] Thereby, the laser beam by which outgoing radiation is carried out from Yb:YAG laser 21 is Y1 as a good beam which only a predetermined polarization component required for laser beam machining etc. is reflected by the beam splitter 12, and a separation extract is carried out and does not have an excessive deviation component in case it goes several times and is amplified between a total reflection mirror 14 and the rear mirror 15. Since it is outputted to a direction and used, process tolerance can be raised. And since it is reflected by the total reflection mirror 14 and the rear mirror 15, and it goes and comes back to other polarization components of a laser beam and they are useful to excitation of Yb:YAG laser 21 by penetrating a beam splitter 12, especially the oscillation effectiveness of a laser beam does not fall by making only a specific polarization component output.

[0042] By the way, what is necessary is just to control the excitation output from LD100 to control the output of a laser medium. However, with the laser oscillation vessel using conventional Nd:YAG, an excitation optical output has the problem from which wavelength changes with laser outputs a little, and the rate of excitation light absorption of a laser medium changes with change of the wavelength of this excitation light. Change of the oscillation wavelength of LD is set also to **3nm to Nd:YAG being 1.5nm of absorption wavelength ****, and, specifically, effect is large. Therefore, when changing the output of LD and changing the output from a laser oscillation machine, it is necessary to also take change of wavelength into consideration, control of LD output and control of LD oscillation wavelength are needed, the control is very difficult and variation becomes the largest.

[0043] However, Yb: The absorption wavelength width of face of YAG laser 21 is about 21nm, is fully large and cannot be easily influenced [of the output of said LD] by it of Nd:YAG of change. Then, with the gestalt of this operation, as for Yb:YAG laser 21, the antireflection film is given to the both sides of the 1st and 2nd end face 21a and 21b to the wavelength of 940nm, and 1030nm in order to harness this more. Thus, Yb to which

the antireflection film was given in the both-ends sides 21a and 21b : The absorption wavelength width of face of YAG laser 21 improves further. since it is markedly alike to the absorption wavelength width of face of said Nd:YAG, it becomes large and the range of fluctuation of the oscillation wavelength of LD is much less than it Even if it changes the laser output from Yb:YAG laser 21 by changing the excitation output from LD100, a problem is lost, and it becomes easy to change a laser output. Even if it omits an antireflection film depending on the case, sufficient output control is made as compared with the conventional case. These descriptions can apply similarly the optical configuration of the gestalt of operation shown in drawing 1 .

[0044] And with the gestalt of this operation, it has the configuration for which the rear mirror 15 is rotated by the surroundings of an optical axis Z by the rolling mechanism 13 by the motor, the pulley, the belt, and others, the ullage of the laser beam from said total reflection mirror 14 is measured as light energy with a monitor 9, and a measurement result is inputted into a controller 16. A controller 16 gives the rotation command according to the measured value and the command value from a monitor 9 to a rolling mechanism 13. It combines with this and is the front face A1 of the rear mirror 15. In a side, the lambda/4-wave film is a tooth back A2. The total reflection film which carries out total reflection of the laser beam is given to the side, respectively.

[0045] The laser beam of the wavelength 1030 which goes and penetrates Yb:YAG laser 21 from one 1st end-face 21a to other-end side 21b by this reaches the rear mirror 15, and is a front face A1. The near lambda/4-wave film and tooth back A2 Plane of polarization is changed with the total reflection film. Then, it is the rear mirror 15 centering on the optical axis Z of a laser beam by the rolling mechanism 13 theta 1 Or theta 2 By rotating a direction, plane of polarization rotates and it is made to reflect by the beam splitter 12, and a division extract can be carried out and the polarization component ratio of the polarization component which carries out outgoing radiation, and other polarization components which are made to penetrate and do not carry out outgoing radiation can be changed.

[0046] When a beam splitter 12 separates, and the laser beam from which the polarization component ratio changed was extracted, for example the light of a polarization component decreases, the output with the extracted fixed polarization component of a laser beam decreases. On the contrary, when the light of a polarization component increases, the output with the extracted fixed polarization component of a laser beam increases. A laser output can be changed using such work, without changing the excitation output of LD100. It compares, when changing the excitation output of the above LD 100 especially, and only the laser beam of a predetermined polarization

component can be outputted with a predetermined output value, the variation in an output decreases further, and there is an advantage whose part process tolerance of the improves. Therefore, unique effectiveness can be demonstrated by the output change independent using a rolling mechanism 13, and output adjustment which has width of face more can be carried out by using together the approach of changing the excitation output of LD100 and changing a laser output.

[0047] The gestalten of operation shown in drawing 3 are short-wavelength-izing and an example at the time of narrow-band-izing and being able to be made to carry out outgoing radiation further, after making an output changed by outputting only a fixed polarization component like the gestalt of operation of the laser beam which carries out outgoing radiation from Yb:YAG laser 21 of said drawing 2 , and changing a polarization component ratio.

[0048] In addition to the configuration of the example of drawing 2 , the etalon 10 is arranged with Q switch 8 and the beam splitter 12 in the location from which it separated further from the optical path of the excitation light of the both-way optical path to which a laser beam is made to go and come back. Specifically, it is arranged between Q switch 8 and the total reflection mirror 14. The glass plate of three sheets was set and an etalon 10 forms into single wavelength the laser beam which carries out incidence. For example, Yb: There is variation in the wavelength for how many minutes in the laser beam by which outgoing radiation is carried out from YAG laser 21, and influence the shape of beam of a laser beam. However, while a laser beam goes, when it passes along an etalon 10, the wavelength of 1031nm which separated from predetermined wavelength, for example, 1030nm, and the ambient light of 1033nm do not penetrate, but are eliminated. Therefore, Yb: The laser beam from YAG laser 21 is narrow-band-ized by the predetermined wavelength region, and is made into it outgoing radiation. Therefore, a laser output good to the pan by which especially the shape of beam was ready and was stabilized is obtained, and it is effective in especially the improvement in process tolerance. Since only a part to be narrow-band-ized reduces a laser output to coincidence, the output of a laser beam can be reduced also by this, without decreasing LD output.

[0049] Moreover, Yb: Although the laser oscillation machine using YAG laser 21 is set to 1030nm as described above, fluorescence width of face is about 9nm. This increases also about 15 times compared with fluorescence width of face of 0.67nm of Nd:YAG. For this reason, when condensing with a condenser lens, a condensing correcting lens, etc., chromatic aberration arises, the so-called pin dotage condition which carries out a focal gap tends to occur, and it becomes the hindrance of micro processing. However,

oscillation wavelength fluorescence width of face can be narrowed by narrow-band-ization by the above etalons 10 etc., such a problem is also solved, and the process tolerance of micro processing improves. In addition, an etalon 10 can prevent that the amount of [which is reflected with an etalon 10] Mitsunari returns in the direction of an optical axis Z, and it carries out a bad influence by being inclined and arranged to the optical axis Z.

[0050] Moreover, it is made to carry out outgoing radiation of the laser beam by which is separated from the laser beam on a both-way optical path by the beam splitter 12, and outgoing radiation is carried out in the Y1 direction through the wavelength sensing element 19. The wavelength sensing element 19 is adjusted so that the laser beam of the advancing polarization component may be suited. Only the required laser beam that does not contain the excessive deviation component of the predetermined deviation components chosen as the wavelength sensing element 19 by said beam splitter 12 further narrow-band-ized by the etalon 10 will carry out incidence, the heat deformation brought to the wavelength sensing element 19 by the excessive polarization component can be prevented, and the beam of the suitable quality of best for thin and short wavelength micro processing in which the shape of beam was ready can be given.

[0051] In addition, as a laser medium of each **** of the LD excitation laser oscillation approach in the gestalt of operation shown in above-mentioned drawing 1 - drawing 3 , and a laser oscillation machine, it can replace with Yb:YAG lasers 1 and 21, and Nd:YVO4 laser can also be used. Since it becomes more highly than Nd:YAG like [this Nd:YVO4 laser] the case of Yb:YAG being oscillation effectiveness about 4 times highly [the rate of the excitation absorption of light] according to increase of the amount of dopes, the operation same as 0.5mm or less can be done so like the case of Yb:YAG.

[0052] The gestalt of operation shown in drawing 4 is an example of laser-beam-machining equipment which was made to perform laser beam machining with the laser oscillation vessel 51 in the gestalt of each operation shown in drawing 1 - drawing 3 . The laser beam by which outgoing radiation was carried out from the laser oscillation machine 51 is fabricated by 1 set of collimator lenses 52 as a condensing means, and makes processing side 58a right-angled to the optical axis in workpiece 58 condense with a predetermined beam diameter. The laser beam which makes processing side 58a condense is deflected with the galvanomirrors 53X and 53Y of a suitable scan means, for example, a pair, scans a processing side 58a top for example, to XY 2-way which intersects perpendicularly, and can be made to carry out micro processing of the processing side 58a top in the range of the scan field XY. The ftheta lens 57 is used as a condensing amendment means so that the image formation condition of also making the

location of a processing side 58a throat condensing uniformly the laser beam which is deflected with said galvanomirrors 53X and 53Y, and is turned to each part of the scan field 59 on processing side 58a may be acquired.

[0053] On the other hand, it superimposes on the condensing optical path by the collimator lens 52 as a condensing means which makes a laser beam condense on processing side 58a although the monitor of the condensing condition of said laser beam and the condition of micro processing by it is carried out and they are processed, and said galvanomirrors 53X and 53Y in the middle and an observation means 56 to picturize through the ftheta lens 57 and to observe are established. It gets down to a right angle with the dichroic mirror 54 which a condensing optical path reflects [dichroic mirror] a laser beam and makes only the predetermined reflected light of processing side 58a penetrate for this observation. Bending, Leading the laser beam from the laser oscillation machine 51 to said galvanomirrors 53X and 53Y, and making it condensed on each scanning point of processing side 58a through the ftheta lens 57 The reflected light from each scanning point when a laser beam is condensed reaches a dichroic mirror 54 through the ftheta lens 57 and said galvanomirrors 53X and 53Y, this is penetrated, and it results in the observation means 56, and image formation of the processing condition in the scanning point is carried out to a CCD sensor etc., and it is picturized.

[0054] It is processible with high precision with control of a laser output using the good laser beam by which the shape of beam and the output which the thermal lensing effect and the heat birefringence mitigated by this taking advantage of each description of each laser oscillation machine shown in above-mentioned drawing 1 - drawing 3 to each , and which were further made into short wavelength and a narrow-band were stabilized , observing the condition of a processing point to processing side 58a at the thing of predetermined conditions .

[0055] By being the galvanomirrors 53X and 53Y of a pair with which a scan means scans a processing side top by the laser beam to the 2-way which intersects perpendicularly Can attain with an easily and sufficient precision by synthetic control of two actuation, and when [of rotation / simple] a condensing auxiliary means is the ftheta lens 57, the scan of the workpiece 58 by the laser beam on a flat surface Since it can be made to be able to condense well in every location on the flat surface of workpiece 58 by one condensing auxiliary means although a flat-surface top is made to scan by said synthetic control and image formation of the laser beam from one point can be carried out to it, micro processing can be attained with high precision.

[0056]

[Effect of the Invention] According to this invention, it replaces with Nd:YAG generally used from the former as a laser medium in LD excitation laser oscillation machine. Yb:YAG By or the thing which use by making Nd:YVO4 into a thin shape, oscillate a laser beam towards the 1st mirror by LD excitation as usual from the 1st end face of one of these, and it is made to go between the 1st and 2nd mirror which sandwiched the laser medium, and is amplified A laser medium is cooled that there is no obstacle of LD excitation from behind the 2nd mirror. while securing sufficient laser output value required for processing -- the 2nd mirror -- the 1st end face of a laser medium, and the 2nd reverse near end face -- reliance -- **** -- Since the variation in temperature distribution including the 1st end face by which LD excitation of the laser medium is carried out when the cooling effect makes it easy to attain to thin whole Yb:YAG becomes small Generating of a thermal lensing effect and the heat birefringence by change of a refractive index is suppressed, the energy of a laser output and fluctuation of the shape of beam can be reduced, stability can be raised, and it is useful to improvement in the further process tolerance.

[0057] Since the laser beam by which outgoing radiation is not carried out by using as a total reflection mirror both mirror of the pair to which the variation in an output decreases further, the part process tolerance improves, and a laser beam is made to go and come back by carrying out the division extract of the predetermined deviation component by the beam splitter, and making the laser beam of a both-way optical path output can be used effectively for excitation of a laser medium, it is easy to acquire a predetermined output value.

[0058] By being what consists of the sapphire or the diamond in which the 2nd mirror had the optical flat surface, high permeability can be offered to a laser beam, thermal conductivity can be good, since the cooling effect of the laser medium by the cooling means in back can be heightened, generating of a thermal lensing effect and a heat birefringence can be suppressed more, and the precision of laser beam machining can be improved more.

[0059] In any case, modulate a laser beam with a Q switch, do not bar pulse-izing a continuous-oscillation condition and outputting it, and by aperture The laser beam from which it separated from the diameter of a convention although it had decreased by reduction of fluctuation of the shape of beam is excepted. Stability of a laser output and improvement in process tolerance can be aimed at, and further, aperture turns and reflects said excepted laser beam in the 1st end face of a laser medium, and can profit and use effectively for excitation and magnification.

[0060] Furthermore, since it of Yb:YAG to which the antireflection film was given to the

absorption wavelength width of face of Nd:YAG in the both-ends side is about ten times and the range of fluctuation of the oscillation wavelength of LD is less than [it], even if it changes the laser output from a laser medium by changing the excitation output from LD, a problem is lost, and it becomes easy to change a laser output.

[0061] And when a laser beam penetrates the lambda/4-wave film of the front face of the 2nd mirror, and the total reflection film of the tooth back of the 2nd mirror, the plane of polarization is changed. It uses that the deviation component ratio to other deviation light which is not extracted by the beam splitter of a predetermined deviation light extracted by the beam splitter changes. The output of a laser beam by which outgoing radiation is extracted and carried out without changing the deviation side of a laser beam, setting up a deviation component ratio freely and changing LD excitation output by rotating the 2nd mirror, carrying out the monitor of the light which leaks from the 1st mirror can be made to fluctuate.

[0062] By these, process tolerance can be improved that it is easy to attain rationalization to various processings.

[0063] By changing into short wavelength only the light which had the fixed polarization component extracted by the beam splitter by the wavelength sensing element in the above Since it seems that damage on a component is brought forward by the exposure of an excessive deviation component, and a thermal lensing effect is caused to a component, and the output of the light after wavelength conversion and the shape of beam are not changed Incidence only of the fixed polarization component can be carried out to a wavelength sensing element, and a short wavelength beam good without the effect of an excessive deviation component can be made to output.

[0064] Moreover, although chromatic aberration arises when fluorescence width of face condenses the laser oscillation machine using Yb:YAG with a condenser lens greatly in the above compared with Nd:YAG, pin dotage tends to take place and it is hard to attain micro processing, since a beam can be more thinly fabricated since wavelength of the light which carries out incidence with an etalon is made into predetermined single wavelength, and the effect of said chromatic aberration can be lost, it is convenient to micro processing.

[0065] As a laser medium of each **** of the above-mentioned LD excitation laser oscillation approach and a laser oscillation machine, it can replace with Yb:YAG and Nd:YVO4 can be used. Since it becomes more highly [the rate of the excitation absorption of light is high, and] than Nd:YAG like [Nd:YVO4] the case of Yb:YAG several times [oscillation effectiveness] according to increase of the amount of dopes, the operation same as 0.5mm or less can be done so like the case of Yb:YAG.

[0066] According to the laser-beam-machining equipment of this invention, detailed processing of workpiece etc. can be attained with high precision, observing the condition of a processing point on the basis of the stable predetermined conditions using the laser beam of mitigation of the heat lens by above-mentioned Yb:YAG or Nd:YVO4, and a heat birefringence, short wavelength, and a narrow-band.

[Brief Description of the Drawings]

[Drawing 1] It is the top view showing the optical configuration of the LD excitation laser oscillation approach in the gestalt of operation of this invention, and a laser oscillation machine.

[Drawing 2] It is the top view showing the optical configuration of LD excitation laser oscillation machine in the gestalt of another operation of this invention.

[Drawing 3] It is the top view showing the optical configuration of LD excitation laser oscillation machine in the gestalt of other operations of this invention.

[Drawing 4] It is the perspective view showing the laser-beam-machining equipment in the gestalt of operation of this invention.

[Drawing 5] It is the top view showing the optical configuration of the conventional laser oscillation machine.

[Drawing 6] It is the top view showing the optical configuration of another conventional laser oscillation machine.

[Description of Notations]

100 LD

1 21 Laser medium

1a, 21a One end face

1b, 21b Other-end side

2 Collimator Lens

4 Output Mirror

5 15 Rear mirror

6 Refrigeration Unit

7 Aperture

7a Hole

8 Q Switch

9 Monitor

10 Etalon

11 Dichroic Mirror

12 Beam Splitter

13 Rolling Mechanism

14 Total Reflection Mirror

16 Controller

19 Wavelength Sensing Element

51 Laser Oscillation Machine

52 Collimator Lens

53X, 53Y Galvanomirror

54 Dichroic Mirror

55 Collimator Lens

56 Observation Means

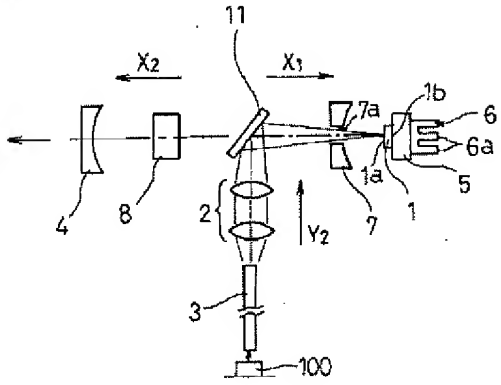
57 FTheta Lens

58 Workpiece

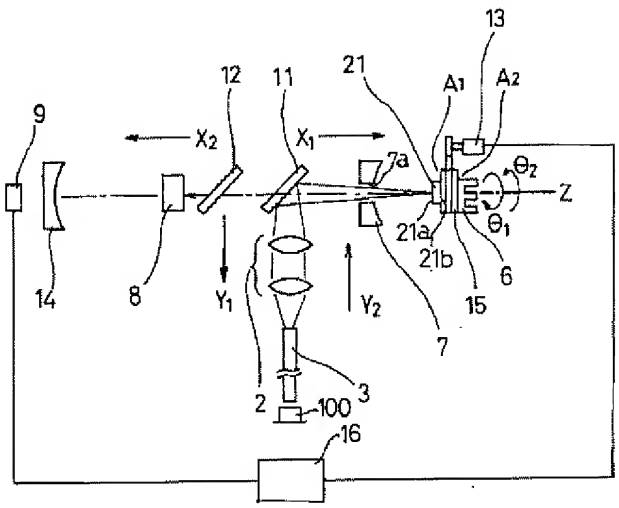
58a Processing side

59 Scanning Zone

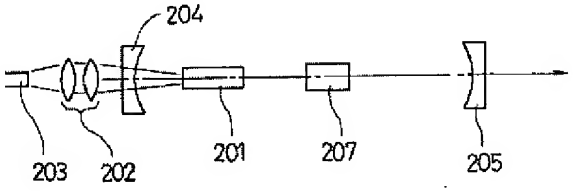
[Drawing 1]



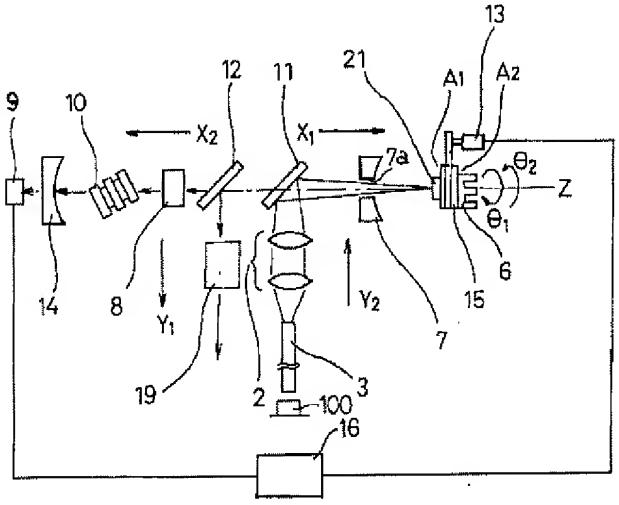
[Drawing 2]



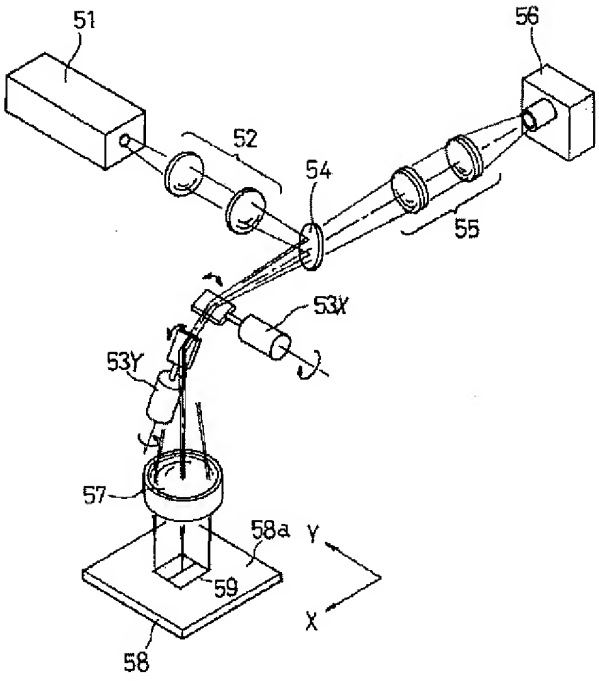
[Drawing 6]



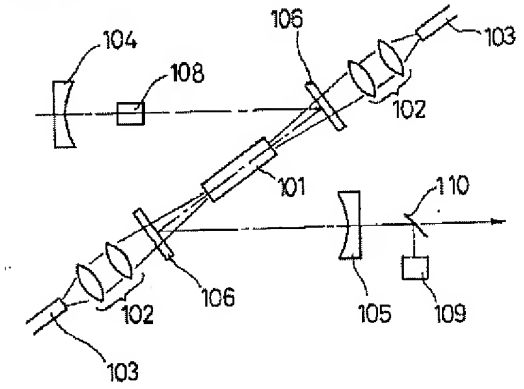
[Drawing 3]



[Drawing 4]



[Drawing 5]



2.**** shows the word which can not be translated.

3.In the drawings, any words are not translated.